

REMARKS

Claims 1-21, 23, and 25-33 will be pending upon entry of the present amendment. Claims 1, 11, and 21 are being amended. Claims 22 and 24 are being canceled. Claims 30-33 are new.

One embodiment of the present invention is directed to a process of manufacturing an integrated device that includes a contact structure formed in a through opening of an insulating layer. Prior art methods typically deposit into the through opening a barrier layer, such as titanium, then fill the through opening with a conductive material, such as tungsten or polysilicon, and then deposit a metal layer (Metal 2) on the contact formed by the conductive fill layer. A major problem with such tungsten or polysilicon contacts occurs if they are employed with ferroelectric capacitors that form part of memory cells. That is because such ferroelectric capacitors are processed at high temperature in the presence of oxygen, which degrades the tungsten or polysilicon and can even cause explosions of the tungsten contacts.

The inventors discovered that the problems associated with tungsten or polysilicon contacts could be avoided simply by not filling the through openings with tungsten, polysilicon, or any other filling material. Instead, the inventors discovered that the contacts can be made solely by the titanium-based barrier layer surrounding an empty region. That is, the Metal 2 layer is non-conformal deposited directly on a top portion of the titanium-based barrier layer to close the empty region and directly contact the barrier layer.

Claims 1-2, 5, 11-12, 15, and 21-23 were rejected under 35 U.S.C. § 102 as being anticipated by U.S. Patent No. 6,436,829 to Layadi et al. ("Layadi").

Layadi does not disclose the invention recited in claim 1, as amended. Amended claim 1 recites a process that includes forming a contact structure having a conductive material layer delimiting an empty region that is open at a top end opposite to the bottom of said through opening; and, without previously depositing a filling material in the empty region, forming a second conductive region that closes the top end of the empty region and delimits, together with the contact structure, the empty region.

Layadi does not disclose forming a second conductive region that closes the top end of the empty region and delimits the empty region, without previously depositing a filling

material in the empty region. Instead, Layadi deposits a tungsten plug 230 in the contact opening 210 before forming a metal trace 560 on the plug. Further, as can be seen in the completed device of Figure 5, the opening 210 is already closed when the metal trace 560 is formed, and thus, the metal trace 560 does not close the top end of the empty region or delimit the empty region.

Although claim 1 was not rejected for obviousness in view of Layadi, the applicants note that amended claim 1 would not have been obvious in view of Layadi. Layadi's entire purpose is to minimize the formation of voids 233 as much as possible. Thus, there is no motivation to modify Layadi to form a second conductive region that closes the top end of the empty region and delimits the empty region, without depositing a filling material in the empty region, as recited in claim 1.

For the foregoing reasons, amended claim 1 is not anticipated or rendered obvious by Layadi.

Claims 2 and 5 depend on claim 1, and thus, are also not anticipated or rendered obvious by Layadi.

Although the language of amended claims 11-12 and 15 is not identical to that of claim 1, the allowability of claims 11-12 and 15 will be apparent in view of the above discussion.

Layadi also does not teach or suggest the invention recited in claim 21, as amended. Amended claim 21 recites a process that includes:

forming a contact structure in the through opening, the contact structure comprising a conductive material layer and an empty region, the conductive material layer being electrically connected to the first conductive region and including a top opening that exposes the empty region; and

forming a conductive cover layer above the contact structure, the cover layer closing the top opening and the empty region, wherein the conductive material layer is formed by steps including:

coating a side surface of the insulating layer, which laterally defines the through opening, with a coating portion of the conductive material layer which laterally defines the empty region; and

forming a horizontal portion of the conductive material layer that extends on top of the insulating layer and beneath the covering layer.

Layadi does not teach or suggest the above-quoted step of forming a conductive cover layer. As discussed above, Layadi does not teach or suggest forming a conductive cover layer that closes a top opening of a contact structure and an empty region. In addition, Layadi does not teach or suggest forming a horizontal portion of the conductive material layer that extends on top of the insulating layer and beneath the covering layer. Instead, Layadi uses a CMP process to etch away the barrier layers 213, 214 and the top of the tungsten layer 236 before the metal trace 560 is formed. As such, the barrier layers 213, 214 are never on top of the insulating layer 201 and beneath the metal trace 260. Accordingly, amended claim 21 is not anticipated or rendered obvious by Layadi.

Claim 23 depends on claim 21, and thus, are also not anticipated or rendered obvious by Layadi.

Claims 1-8 and 21-28 were rejected under 35 U.S.C. § 103 as being unpatentable over U.S. Patent No. 6,376,369 to Doan in view of U.S. Patent No. 6,355,545 to Ohba.

Doan and Ohba do not teach or suggest the invention recited in amended claim 1. Like Layadi, Doan and Ohba are both directed to methods of minimizing the formation of voids in tungsten or aluminum plugs as much as possible. As such, Doan and Ohba do not suggest forming a second conductive region that closes the top end of the empty region and delimits the empty region, without depositing a filling material in the empty region. In Doan, an aluminum-alloy fill layer 116 is deposited before a second conductive layer 118, and thus, the second conductive layer 118 does not close the top end or delimit an empty region. In Ohba, fill material 101 is deposited in the via hole without forming an empty region that is closed by a second conductive region. Accordingly, amended claim 1 is nonobvious in view of Doan and Ohba.

Claims 2-8 depend on claim 1, and thus, are also nonobvious in view of Doan and Ohba.

Although the language of amended claims 21, 23, and 25-28 is not identical to that of claim 1, the allowability of claims 21, 23, and 25-28 will be apparent in view of the above discussion.

Doan and Ohba also do not teach or suggest the invention recited in claim 25. Claim 25 recites a process that includes forming a titanium nitride layer that defines the empty region. The Examiner admitted that Doan and Ohba do not disclose such a step, but the Examiner took official notice of the equivalence of tungsten and titanium nitride as barrier and interconnect materials. The applicants do not agree. Tungsten is not used as a barrier material because it does not provide the adhesiveness or barrier properties that are provided by titanium nitride and titanium nitride is not used as an interconnect plug by itself because it does not provide nearly the conductivity of tungsten. In fact, if titanium nitride and tungsten were interchangeable, then there would be no need for both titanium nitride barrier layers and tungsten plugs in the same contact structure. Titanium nitride is used as a barrier layer because of tungsten's failure as a barrier layer and a tungsten plug is used because of titanium nitride's failure as a conductive plug material. Accordingly, claim 25 is nonobvious in view of Doan and Ohba.

Claims 13-14 and 16-19 were rejected under 35 U.S.C. § 103 as being unpatentable over Layadi in view of Doan.

Layadi and Doan do not teach or suggest the invention recited in claims 13-14 and 16-19, which depend on claim 11. As discussed above, Layadi and Doan do not teach or suggest the step of "without previously depositing a filling material in the empty region, forming a second conductive region that closes the top opening and defines, together with the conductive material layer, the empty region." Instead, both Layadi and Doan are directed to minimizing voids in conductive fill materials, rather than closing an opening in an empty region without previously depositing a filling material in the empty region. Accordingly, claims 13-14 and 16-19 are nonobvious in view of Layadi and Doan.

Claims 9-10, 20, and 29 were rejected under 35 U.S.C. § 103 as being unpatentable over EP Publication No. 0793274 to Jones et al. ("Jones") in view of Doan and Ohba, or Layadi and Doan, or Layadi.

The cited prior art does not teach or suggest the invention recited in claims 9-10, which depend on claim 1. In particular, Jones does not teach or suggest the features of claim 1 that are missing from Layadi, Doan, and Ohba. That is, Jones does not teach or suggest forming a second conductive region that closes the top end of an empty region and delimits the empty region, without previously depositing a filling material in the empty region. Instead, Jones simply teaches that conductive contacts 63 are formed by conventional processing steps (page 4, lines 54-56). As a result, claims 9-10 are nonobvious in view of the cited prior art.

Although the language of amended claims 20 and 29 is not identical to that of claims 9-10, the allowability of claims 20 and 29 will be apparent in view of the above discussion.

The Director is authorized to charge any additional fees due by way of this Amendment, or credit any overpayment, to our Deposit Account No. 19-1090.

All of the claims remaining in the application are now clearly allowable. Favorable consideration and a Notice of Allowance are earnestly solicited.

Respectfully submitted,

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